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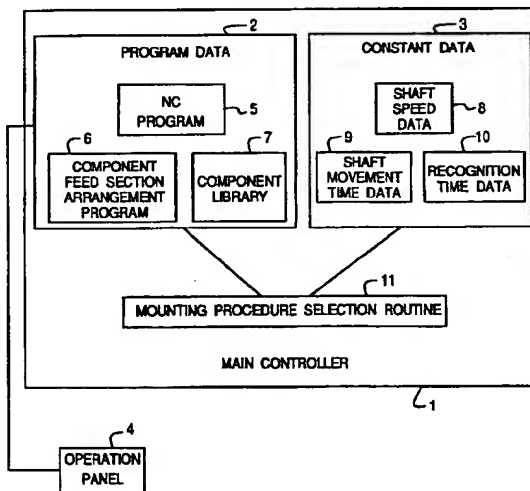
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**(54) METHOD AND APPARATUS FOR MOUNTING ELECTRONIC COMPONENTS**

(57) In a method and an apparatus for mounting of electronic components onto a board, there are provided a head section (35) having a plurality of nozzles (12, 13) for sucking electronic components and a recognition camera (15) for recognizing a posture of sucked electronic component through its image and, a control component (1) for controlling the head section so that after the electronic components at a component feed section (30) are sucked by the nozzles, the sucked posture is image-recognized by the recognition camera and corrected, wherein a main controller (1) is provided with a mounting procedure selection routine (11) for selectively driving the head section while one board is subjected to mounting, according to a first mounting procedure whereby one component is sucked and the sucked component is mounted by one of the nozzles and a different component is sucked and the sucked component is mounted by the other of the nozzles and according to a second mounting procedure whereby electronic components sucked by two nozzles are consecutively mounted after one electronic component is sucked by one nozzle and the other electronic component is sucked by the other nozzle.

Fig.2



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## Description

### TECHNICAL FIELD

The present invention relates to a method and an apparatus for mounting electronic components on boards.

### BACKGROUND ART

In these days, shortening of a time for mounting electronic components is increasingly required to improve productivity.

Hereinbelow, an example of a conventional electronic component mounting apparatus will be described with reference to the drawings. Fig. 12 schematically illustrates the whole constitution of a conventional mounting apparatus. In Fig. 12, 30 is an electronic component feed section for supplying an electronic component 31, and 32 is a board. 35 is a head section having two, i.e., a first and a second suction nozzles 12, 13 and a recognition camera 15. 33 is an X-axis table moving the head section 35 in an X-axis direction, and 34 is a Y-axis table moving the head section 35 in a Y-axis direction orthogonal to the X-axis direction which is a direction of the move of the head section 35 by the X-axis table 33. The head section 35 is positioned at an optional position by the X-axis and Y-axis tables 33, 34. 101 is a main controller for the mounting apparatus and 104 is an operation panel of the apparatus.

In the conventional mounting apparatus of this type, the electronic component 31 in the component feed section 30 is mounted to the board 32 by the head section 35 in a single mounting procedure. That is, sucking of one component and mounting of one component are alternately carried out repeatedly.

The mounting procedure at the head section 35 is diagrammatically represented in Figs. 3A-3J. Fig. 5 is a timing chart of the procedure. A part shown by inclined lines in the timing chart from the "movement of the head section" to the "corrective rotation of the second nozzle" excluding the "recognition" process represents where the head section 35 is being driven, and a part of horizontal lines is where the head section 35 is stopped driving. In the recognition process, upper straight parts are where the recognition process is executed, lower straight parts are where the recognition process is stopped and fine sawtoothed parts are where the recognition process is kept standby by a timer. After receiving a movement completion signal of a slide unit 14, a mirror in the slide unit 14 is vibrated consequent to the movement of the slide unit 14. The recognition process is not started until the vibration of the mirror is stopped, and the above standby time is secured for the mirror to stop vibrating. Referring to Figs. 3A-3J, 12 is the first nozzle in the head section 35 and, 13 is the second nozzle also set in the head section 35 together with the first nozzle 12. 14 is the slide unit having a plurality of

reflecting mirrors and set in the head section 35, and the slide unit 14 transmits a light image of the electronic component 31 sucked by the first or second nozzle 12, 13 to the recognition camera 15 of the head section 35 via the reflecting mirrors thereof. In the head section 35, the slide unit 14 moves in a horizontal direction between the first and second nozzles 12 and 13 to the recognition camera 15. The light image of the electronic component sucked by the first nozzle 12 is transmitted to the recognition camera 15 via the slide unit 14 at the side of the first nozzle 12. On the other hand, the light image of the electronic component sucked by the second nozzle 13 is transmitted to the recognition camera 15 via the slide unit 14 at the side of the second nozzle 13.

In the first place, the head section 35 is moved through the movement of the X-axis and Y-axis tables 33, 34 to a suction position 19 of the feed section 30 by the first nozzle 12 (Fig. 3A). When the head section 35 is completely moved to the suction position 19 of the feed section 30, the first nozzle 12 descends, thereby sucking an electronic component 17 located at the suction position 19 (Fig. 3B). At this time, the second nozzle 13 is at a raised position and the slide unit 14 is set at the side of the second nozzle 13, so that the first nozzle 12 is allowed to move up and down. After the sucking of the electronic component 17 by the first nozzle 12 is completed, the first nozzle 12 moves upward and the head section 35 starts to move to a mounting position 20 of the board 32 for an electronic component 16 which has been sucked by the second nozzle 13 in a previous sucking operation (Fig. 3C). During the time when the head section 35 is moved to the suction position 19, the electronic component 17 is sucked by the first nozzle 12 and the head section 35 is moved to the mounting position 20, a sucked posture of the electronic component 16 by the second nozzle 13 is recognized by the recognition camera 15 via the slide unit 14, and the posture of the electronic component 16 to the head section 35 is corrected. As is well known, this correction is executed by minutely moving the second nozzle 13 to an optional position in the X-axis and Y-axis directions, or rotating the second nozzle 13 about its center axis. When the first nozzle 12 moves up completely, the slide unit 14 moves towards the first nozzle 12 (Fig. 3D). Upon completion of the movement of the slide unit 14 to the first nozzle 12 and of the head section 35 to the mounting position 20 of the board 32 for the electronic component 16 sucked by the second nozzle 13, the second nozzle 13 moves down to mount the sucking electronic component 16 to the mounting position 20 on the board 32 (Fig. 3E).

When the second nozzle 13 completes the mounting of the electronic component 16 to the board 32, the second nozzle 13 moves upward and the head section 35 starts to move to a suction position 21 over the feed section 30 for a next electronic component 18 by the second nozzle 13 (Fig. 3F). When the head section 35 reaches the suction position 21 for the electronic com-

ponent 18 by the second nozzle 13, the second nozzle 13 moves down to suck the electronic component 18 at the suction position 21 (Fig. 3G). After the second nozzle 13 completely sucks the electronic component 18, the second nozzle 13 moves up and the head section 35 starts to move to a mounting position 22 of the board 32 for the electronic component 17 sucked by the first nozzle 12 (Fig. 3H). During this time while the head section 35 moves to the suction position 21, the second nozzle 13 sucks the electronic component 18 and the head section 35 moves to the mounting position 22, a posture of the electronic component 17 sucked by the first nozzle 12 is recognized by the recognition camera 15. The posture of the electronic component 17 to the head section 35 is corrected by minutely moving the first nozzle 12 to an optional position in the X- and Y-axes directions or rotating the first nozzle 12 about its central axis, as is known well. When the second nozzle 13 completely moves up, the slide unit 14 moves towards the second nozzle 13 (Fig. 3I). When the slide unit 14 comes to the side of the second nozzle 13 and the head section 35 completely moves to the mounting position 22 of the board 32 for the electronic component 17 sucked by the first nozzle 12, the first nozzle 12 moves down to mount the sucking electronic component 17 to the mounting position 22 of the board 32 (Fig. 3J). When completing the mounting of the electronic component 17, the first nozzle 12 moves up and the head section 35 starts to move to a suction position for a next electronic component 17 (Fig. 3A). This sequence of operations is repeated afterwards to sequentially mount electronic components.

According to the mounting procedure as above, the head section 35 reciprocates for every electronic component between the feed section 30 and the board 32. Therefore, a mounting time is easily adversely influenced by a distance between the suction position of the feed section 30 and the mounting position of the board 32. The mounting time is increased as the distance is lengthy. In other words, the above single mounting procedure generates a loss time if adopted to a board having mounting points elongating the distance of the move of the head section 35. Since the mounting procedure includes unfavorable circumstances as above to increase the mounting time in each process, the single use of the mounting procedure accompanies a loss in mounting time per one board.

The present invention has for its object to provide a method and an apparatus for mounting electronic components whereby a loss in mounting time caused by a single mounting procedure is reduced, thereby to shorten the mounting time per one board.

## DISCLOSURE OF INVENTION

According to one aspect of the present invention, there is provided a method for mounting electronic components in a corrected suction posture onto a board,

whereby electronic components of an electronic component feed section are sucked by nozzles with the use of a head section having a plurality of nozzles for sucking the electronic components of the feed section and a recognition camera for recognizing a posture of the electronic component sucked by each of the nozzles through images, then a sucked posture of the electronic component is image-recognized by the recognition camera and corrected, by selectively driving the head section while electronic components are mounted to one board, according to a first mounting procedure so that one of the plurality of nozzles sucks and mounts one electronic component and then the other nozzle sucks and mounts a different electronic component and according to a second mounting procedure so that the plurality of nozzles suck electronic components consecutively and then mount the sucked electronic components consecutively.

According to another aspect of the present invention, there is provided an apparatus for mounting electronic components onto a board, which comprises a head section having a plurality of nozzles for sucking electronic components of an electronic component feed section and a recognition camera for recognizing a posture of the electronic component sucked by each of the nozzles through its image, and a control part which controls the head section so that after the nozzles suck the electronic components of the component feed section, the recognition camera recognizes a sucked posture of the electronic component through its image, whereby the posture of the component is corrected and the electronic components are mounted on the board, wherein the control part is provided with a mounting procedure selection means for selectively driving the head section while electronic components are mounted to one board, according to a first mounting procedure whereby one of the plurality of nozzles sucks and mounts one electronic component and then the other nozzle sucks and mounts a different electronic component and according to a second mounting procedure whereby the plurality of nozzles suck electronic components consecutively and then mount the sucked electronic components consecutively.

According to the mounting method and apparatus of the present invention, while one board is subjected to mounting of electronic components, the head section is selectively driven according to the first mounting procedure whereby one electronic component is completely sucked and mounted and then a next electronic component is sucked and mounted, and according to the second mounting procedure whereby two electronic components are sucked and then mounted. When a suitable one of the mounting procedures is selected, a loss in mounting time generated if the mounting is carried out in one single procedure is decreased. The mounting time for every board is shortened.

For instance, if a time required in each mounting procedure is calculated before the start of mounting and

the mounting procedure of a shorter required time is automatically selected, the mounting time for each board is automatically reduced.

If an operator selects from the two mounting procedures, the mounting procedures can be optionally used.

## BRIEF DESCRIPTION OF DRAWINGS

These and other aspects and features of the present invention will become clear from the following description taken in conjunction with the preferred embodiments thereof with reference to the accompanying drawings, in which:

Fig. 1 is a perspective view showing the total schematic constitution of an electronic component mounting apparatus according to one embodiment of the present invention;

Fig. 2 is a block diagram of a control part in the mounting apparatus of the embodiment;

Figs. 3A, 3B, 3C, 3D, 3E, 3F, 3G, 3H, 3I, and 3J are diagrams respectively diagrammatically explaining processes in a first mounting procedure in the embodiment;

Figs. 4A, 4B, 4C, 4D, 4E, 4F, 4G, 4H, 4I, 4J, 4K, and 4L are diagrams respectively diagrammatically explaining processes in a second mounting procedure in the embodiment;

Fig. 5 is a timing chart of the first mounting procedure in the embodiment;

Fig. 6 is a timing chart of the second mounting procedure in the embodiment;

Fig. 7 is a flow chart of a routine for calculating a mounting time of each procedure in the embodiment;

Figs. 8A and 8B are explanatory diagrams of the first and second mounting procedures schematically showing a state where a head section is moved in the embodiment;

Figs. 9A and 9B are explanatory diagrams of an equal velocity movement of an X-axis table and a Y-axis table used for calculating the mounting time in the embodiment when a maximum velocity is achieved and when the maximum velocity is not achieved;

Fig. 10 is an explanatory diagram of parameters used for calculating the mounting time in the embodiment;

Fig. 11 is a comparative diagram of mounting times in the two mounting procedures in the embodiment; and

Fig. 12 is a perspective view of the total schematic constitution of a conventional electronic component mounting apparatus.

ceeds, it is to be noted that like parts are designated by like reference numerals through the attached drawings.

An electronic component mounting apparatus according to one embodiment of the present invention will be described with reference to Figs. 1-11 hereinbelow. In the apparatus according to the embodiment shown in Fig. 1, mechanical specifications of the component feed section 30 for supplying electronic components, X-axis table 33, Y-axis table 34 and head section 35 including the first nozzle 12, second nozzle 13, recognition camera 15 and slide unit 14, etc. apply equally to corresponding parts of the conventional apparatus of Fig. 12, the description of which will therefore be omitted here.

Fig. 2 is a block diagram of a main controller 1 as a control part of the mounting apparatus of the embodiment. In Fig. 2, the main controller 1 is provided with a program data 2, a constant data 3, and programs for a mounting procedure selection routine 11 to be executed with the utilization of the program data 2 and constant data 3. The main controller 1 controls operations of the electronic component feed section 30, X-axis table 33, Y-axis table 34 and head section 35 having the first nozzle 12, second nozzle 13, recognition camera 15 and slide unit 14, etc.

The program data 2 includes an NC program 5, a component feed section arrangement program 6 and a component library 7. In the NC program 5 are described mounting orders for electronic components, mounting positions for the electronic components on the board 32, layout Nos. of the electronic components sucked by the nozzles 12 and 13 at the component feed section 30, mounting procedures of the using head section 35 and the like data. The arrangement program 6 contains data such as arrangements or layout manners, suction positions for the electronic components, etc. in the component feed section 30. The component library 7 contains data such as dimensions and feeding directions of the components, stages of moving speeds of the X-axis table 33 and Y-axis table 34 at the sucking time of the electronic components, etc. These programs and data can be edited through an operation panel 4 of the mounting apparatus of the embodiment.

The constant data 3 includes a shaft speed data 8, a shaft movement time data 9 and a recognition time data 10. The shaft speed data 8 includes such data as shaft speeds and accelerations of a screw shaft connected to a rotary shaft of an AC servo motor driving the X-axis table 33, a screw shaft connected to a rotary shaft of an AC servo motor driving the Y-axis table 34, a screw shaft connected to a rotary shaft of a motor moving the slide unit 14, set values of timers for delaying a driving start, and the like. The shaft movement time data 9 includes data, e.g., times required for the first and second nozzles 12, 13 to move up and down, a time required for the slide unit 14 to move, etc. The recognition time data 10 contains data required for recognizing the electronic components and for calculating and cor-

## BEST MODE FOR CARRYING OUT THE INVENTION

Before the description of the present invention pro-

recting postures of the electronic components. The above shaft movement time data 9 and recognition time data 10 will be detailed later with reference to Fig. 10.

In the mounting procedure selection routine 11, before mounting of the electronic components is started, a mounting time of the head section 35 in each procedure is calculated based on the above-described data, so that the procedure of the smallest time is selected. The mounting procedure selection routine 11 will be described later with reference to Figs. 3A to Fig. 10.

Two mounting procedures in the embodiment will be depicted now. A first mounting procedure is the same as the conventional example described with reference to Figs. 3A-3J. Fig. 5 is the timing chart of the procedure. Sucking of one component and mounting of another component are alternately repeatedly carried out according to the first procedure.

A second mounting procedure is a freshly added procedure to the mounting apparatus, which is diagrammatically shown in Figs. 4A-4L. Fig. 6 is a timing chart of the second mounting procedure, in which a part of inclined lines corresponds to a being-driven period from the "movement of the head section" to the "corrective rotation of the second nozzle" excluding the "recognition" process, and a part of horizontal lines is where the apparatus stops operating. Meanwhile, upper straight lines in the recognition process indicate when the recognition process is carried out, and lower straight lines indicate when the recognition process is stopped. Fine sawtoothed parts are standby times set by the timer. Since the recognition process is conducted after the mirror in the slide unit 14 vibrates and stops its vibration resulting from the movement of the slide unit 14 after receiving a movement completion signal of the slide unit 14, the standby time is provided to wait for the mirror to stop vibrating. According to the second mounting procedure, nozzles 12, 13 sequentially suck electronic components and then sequentially mount the components. This second mounting procedure will be described with reference to Figs. 4A-4L and 6.

The head section 35 is moved by the X-axis and Y-axis tables 33 and 34 to a suction position 25 of the feed section 30 for an electronic component 23 by the first nozzle 12 (Fig. 4A). When the head section is perfectly moved to the suction position 25 by the first nozzle 12, the first nozzle 12 comes down to suck the electronic component 23 at the suction position 25 (Fig. 4B). When the electronic component 23 is completely sucked by the first nozzle 12, the first nozzle 12 moves up and the head section 35 starts to move to a suction position 26 of the feed section 30 for an electronic component 24 by the second nozzle 13 (Fig. 4C). Upon completion of the rise of the first nozzle 12, the slide unit 14 moves to the first nozzle 12 (Fig. 4D). When the slide unit 14 finishes the movement and the head section 35 finally reaches the suction position 26 of the second nozzle 13 for the electronic component 24, the second

nozzle 13 descends to suck the electronic component 24 at the suction position 26 (Fig. 4E).

When the second nozzle 13 finishes sucking of the electronic component 24, the second nozzle 13 moves upward and the head section 35 starts to move to a mounting position 27 of the board 30 for the electronic component 23 sucked by the first nozzle 12 (Fig. 4F). While the second nozzle 13 sucks the electronic component 24 and the head section 35 moves to the mounting position 27, a posture of the electronic component 23 sucked by the first nozzle 12 is recognized by the recognition camera 15, and a correction calculation is started to correct the sucked posture. After the correction calculation is completed through the recognition, the slide unit 14 moves to the side of the second nozzle 13 (Fig. 4G). At the same time, a suction posture of the first nozzle 12 to the head section 35 is corrected on the basis of the correction calculation. After the slide unit 14 completes moving and the head section 35 completely moves to the mounting position 27 for the electronic component 23 sucked by the first nozzle 12, the first nozzle 12 moves down thereby to mount the electronic component 23 to the mounting position 27 of the board 30 (Fig. 4H).

When the first nozzle 12 completely mounts the electronic component 23 to the board 30, the first nozzle 12 then moves up and the head section 35 moves to a mounting position 28 of the board 30 for the electronic component 24 sucked by the second nozzle 13 (Fig. 4I). While the first nozzle 12 mounts the electronic component 23 to the board 30 and the head section 35 moves to the mounting position 28, the recognition camera 15 recognizes a suction posture of the electronic component 24 sucked by the second nozzle 13, and a correction calculation is started to correct the posture. After completion of the correction calculation based on the recognition, the slide unit 14 moves to the side of the first nozzle 12 (Fig. 4J) and moreover, a sucking posture of the second nozzle 13 to the head section 35 is corrected on the basis of the result of the correction calculation. After the movement of the slide unit 14 and also the movement of the head section 35 to the mounting position 28 on the board 30 for the electronic component 24 sucked by the second nozzle 13 are completed, the second nozzle 13 descends, thereby mounting the sucking electronic component 24 to the mounting position 28 of the board 30 (Fig. 4K).

After the mounting by the second nozzle 13 is finished, the second nozzle 13 moves up and the head section 35 starts to move to a suction position 29 of the feed section 30 for an electronic component 123 to be sucked next by the second nozzle 13 (Fig. 4L). Subsequently, the mounting procedure is carried out with the first nozzle 12 and second nozzle 13 reversed in order. Electronic components are mounted by repeating a sequence of the above-described operations.

According to the mounting apparatus of the embodiment, a mounting procedure selection column in the

NC program 5 is edited with the use of the operation panel 4, and therefore one of the two mounting procedures can be optionally selected and set.

The mounting procedure selection routine 11 will be described with reference to Figs. 3A-10.

Fig. 7 is a flow chart of the mounting procedure selection routine 11. According to the routine 11, in the first place, moving distances  $d_1$ - $d_4$ ,  $d_1'$ - $d_4'$  of the head section 35 are calculated (step S1). Moving times  $m(d_1)$ - $m(d_4)$ ,  $m(d_1')$ - $m(d_4')$  of the head section 35 are then calculated (step S2). Times T1, T2 in respective procedures are calculated (step S3). A faster one of the procedures is selected (step S4). The mounting procedure selection routine 11 is started when  $n > 2$  and  $n$  is an odd number when an (n)th electronic component is to be sucked by the first, second nozzle 12, 13.

Figs. 8A and 8B are diagrams of the movement of the head section 35, specifically, Fig. 8A shows the movement in the first mounting procedure and Fig. 8B corresponds to the second mounting procedure. Either of the mounting procedures requiring a larger moving distance of the X-axis and Y-axis tables 33, 34 is detected in the routine 11. Concretely, moving distances  $d_1$ - $d_4$  in Fig. 8A and moving distances  $d_1'$ - $d_4'$  in Fig. 8B are obtained according to the NC program 5 and arrangement program 6. Calculation formulae are as follows.

$$\begin{aligned} d_1 &= \max(|x_{n-2} - x_{zn}|, |y_{n-2} - y_{zn}|) \\ d_2 &= \max(|x_{n-1} - x_{zn} + b|, |y_{n-1} - y_{zn}|) \\ d_3 &= \max(|x_{n-1} - x_{zn+1}|, |y_{n-1} - y_{zn+1}|) \\ d_4 &= \max(|x_n - x_{zn+1} - b|, |y_n - y_{zn+1}|) \\ d_1' &= (|x_{n-1} - x_{zn-2}|) \\ d_2' &= \max(|x_{n-1} - x_{zn}|, |y_{n-1} - y_{zn}|) \\ d_3' &= |x_{zn+1} - x_{zn} - b| \\ d_4' &= \max(|x_n - x_{zn+1} + b|, |y_n - y_{zn+1}|) \end{aligned}$$

" $X_n$ " is an x coordinate of the mounting position of the (n)th electronic component to the board 30 and, " $y_n$ " is a y coordinate of the mounting position of the same electronic component. " $z_n$ " is an (n)th layout No. at the feed section 30. " $x_{zn}$ " is accordingly an x coordinate of the suction position of the electronic component at the layout No.  $z_n$ . " $y_{zn}$ " is a y coordinate of the suction position of the electronic component at the layout No.  $z_n$ . "max(i,j)" is a function to obtain a larger one of i and j, and "b" is a distance between the two nozzles 12 and 13.

In the selection routine 11, then, times required for the X-axis table 33 or Y-axis table 34 to move the distances  $d_1$ - $d_4$  or  $d_1'$ - $d_4'$  are calculated, which will be dis-

cussed in detail with reference to Figs. 9A and 9B.

Figs. 9A and 9B are diagrams of the movement of the Y-axis and Y-axis tables 33 and 34. Calculations in the selection routine 11 are based on condition that the tables move at an equal acceleration. In Figs. 9A and 9B, " $V_{max}$ " is a maximum velocity (unit: pulse/s) determined for each speed stage and " $V'_{max}$ " is an achieved maximum velocity (unit: pulse/s), holding a relation of  $V'_{max} < V_{max}$ . " $\alpha$ " is an acceleration (unit: pulse/s<sup>2</sup>) of each screw shaft of the X-axis and Y-axis tables 33 and 34, "d" is a moving distance (unit: mm) of each screw shaft and, "m(d)" is a time (unit: s) required for moving the distance d. The "pulse" in the unit of the above velocity and acceleration indicates a driving pulse of the AC servo motor of the X-axis table 33, Y-axis table 34. Fig. 9A is the diagram when the tables move at an equal velocity after achieving the determined maximum velocity. On the other hand, Fig. 9B shows the case when they do not reach the determined maximum velocity.

Since 500(pulse) of the encoder built in the AC servo motor corresponds to 1(mm), the function m(d) of the required moving time of the X-axis table 33 or Y-axis table 34 for the moving distance d is detected based on Figs. 9A, 9B as follows.

$$\text{When } \sqrt{500\alpha d} \geq V_{max},$$

$$m(d) = V_{max}/\alpha + 500d/V_{max}$$

$$\text{When } \sqrt{500\alpha d} < V_{max},$$

$$m(d) = 2\sqrt{500\alpha d}$$

In the above expressions, "sqrt" is a function for obtaining a square. Values of  $V_{max}$  and  $\alpha$  can be obtained from the shaft speed data 8 on the basis of the speed stage of the head section 35 in the component library 7.

The time required for the X-axis table 33 or Y-axis table 34 to move the distances  $d_1$ - $d_4$ ,  $d_1'$ - $d_4'$  is calculated with the use of the function m(d) in the selection routine 11.

Thereafter, the mounting time in each mounting procedure is calculated based on the timing charts of Figs. 5, 6 by the selection routine 11. Fig. 10 indicates parameters used in calculating the mounting times in the selection routine 11, which are included in the shaft movement time data 9 and recognition time data 10. Symbols h, a, s and r in Fig. 10 correspond to those in Figs. 5, 6.

Each parameter in Fig. 10 will be described below. A sucking/mounting time h (unit: s) is a time interval after the first and second nozzles 12, 13 start to descend, through the suction of the components, until the first and second nozzles 12, 13 finish to move up. Values of the sucking/mounting time h of the first and second nozzles 12, 13 in every speed stage are

described in the shaft movement time data 9. An arch motion time  $a$  (unit: s) is a time while both the movement of the X-axis table 33 or Y-axis table 34 and the up-down movement of the first and second nozzles 12, 13 are conducted at the same time, with a front end of each nozzle moving in a locus of an arch. Values of the arch motion time  $a$  of the head section 35 and the first and second nozzles 12, 13 for every speed stage are described in the shaft movement time data 9. A moving time  $s$  (unit: s) of the slide unit 14 is a time required for the slide unit 14 to move from one nozzle towards the other nozzle. Values of the moving time  $s$  of the slide unit 14 for every speed stage are described in the shaft movement time data 9. A sucking posture recognition time  $r$  (unit: s) is a time after the timer is started to secure a vibration counteractive time (standby time before the vibration of the mirror incorporated in the slide unit 14 which is caused due to the movement of the slide unit 14 is stopped) after the completion of the movement of the slide unit 14 before an image of the sucked electronic component is taken in and the amount for correcting the sucked posture is finished to be calculated. The sucking posture recognition time  $r$  required for every electronic component is described in the recognition time data 10.

The mounting time of each procedure is calculated by the selection routine 11 with the use of the following expressions from times  $m(d_1)$ - $m(d_4)$ ,  $m(d_1')$ - $m(d_4')$  required by the X-axis table 33 or Y-axis table 34 to move the distances  $d_1$ - $d_4$ ,  $d_1'$ - $d_4'$ , shaft movement time data 9 and recognition time data 10.

A mounting time  $T1$  (unit: s) of the first mounting procedure is calculated according to expressions below.

- (1) When  $m(d_2) < 2a + s$  and  $m(d_4) < 2a + s$ ,  
 $T1 = (m(d_1) + m(d_3) + 4h - 4a + 2s) / 2$
- (2) When  $m(d_2) \geq 2a + s$  and  $m(d_4) < 2a + s$ ,  
 $T1 = (m(d_1) + m(d_2) + m(d_3) + 4h - 6a + s) / 2$
- (3) When  $m(d_2) < 2a + s$  and  $m(d_4) \geq 2a + s$ ,  
 $T1 = (m(d_1) + m(d_3) + m(d_4) + 4h - 6a + s) / 2$
- (4) When  $m(d_2) \geq 2a + s$  and  $m(d_4) \geq 2a + s$ ,  
 $T1 = (m(d_1) + m(d_2) + m(d_3) + m(d_4) + 4h - 8a) / 2$

A mounting time  $T2$  (unit: s) of the second mounting procedure is calculated according to expressions below

- (1) When  $m(d_1') < r - h + 2a + s$ ,  $m(d_3') < 2a + s$ , and  $m(d_4') < r - h + 2a + a$ ,  
 $T2 = (m(d_2') + 2h - 2a + 3s + 2r) / 2$
- (2) When  $m(d_1') \geq r - h + 2a + s$ ,  $m(d_3') < 2a + s$ , and  $m(d_4') < r - h + 2a + a$ ,  
 $T2 = (m(d_1') + m(d_2') + 3h - 4a + 2s + r) / 2$
- (3) When  $m(d_1') < r - h + 2a + s$ ,  $m(d_3') \geq 2a + s$ , and  $m(d_4') < r - h + 2a + a$ ,  
 $T2 = (m(d_2') + m(d_3') + 2h - 4a + 2s + 2r) / 2$
- (4) When  $m(d_1') \geq r - h + 2a + s$ ,  $m(d_3') \geq 2a + s$ , and  $m(d_4') < r - h + 2a + a$ ,  
 $T2 = (m(d_1') + m(d_2') + m(d_3') + 3h - 6a + s + r) / 2$

(5) When  $m(d_1') < r - h + 2a + s$ ,  $m(d_3') < 2a + s$ , and  $m(d_4') \geq r - h + 2a + a$ ,  
 $T2 = (m(d_2') + m(d_4') + 3h - 4a + 2s + r) / 2$

(6) When  $m(d_1') \geq r - h + 2a + s$ ,  $m(d_3') < 2a + s$ , and  $m(d_4') \geq r - h + 2a + a$ ,  
 $T2 = (m(d_1') + m(d_2') + m(d_4') + 4h - 6a + s) / 2$

(7) When  $m(d_1') < r - h + 2a + s$ ,  $m(d_3') \geq 2a + s$ , and  $m(d_4') \geq r - h + 2a + a$ ,  
 $T2 = (m(d_2') + m(d_3') + m(d_4') + 3h - 6a + s) / 2$

(8) When  $m(d_1') \geq r - h + 2a + s$ ,  $m(d_3') \geq 2a + s$ , and  $m(d_4') \geq r - h + 2a + a$ ,  
 $T2 = (m(d_1') + m(d_2') + m(d_3') + m(d_4') + 4h - 8a) / 2$

The mounting procedure selection routine 11 selects a faster procedure based on the calculated mounting times  $T1$  and  $T2$ .

Fig. 11 is a diagram of a relation of the moving distance of the head section 35, namely, a larger moving distance of the X-axis table 33 and Y-axis table 34 and the mounting time in two mounting procedures, which can be compared in Fig. 11.

The above calculations are on the assumption that

$$m(d_1) = m(d_2) = m(d_3) = m(d_4) = m(d_2') = m(d_4')$$

$$m(d_1') < r - h + 2a + s$$

$$m(d_3') < 2a + s$$

$$h = 0.190, a = 0.070, s = 0.080, r = 0.300$$

It is clear from Fig. 11 that the second mounting procedure is faster than the first mounting procedure when the moving distance of the head section 35, i.e., larger one of the moving distances of the X-axis table 33, Y-axis table 34 exceeds 213.3 (mm).

According to the present embodiment as described hereinabove, the head section 35 can be driven according to the first procedure and according to the second procedure. The mounting time of each procedure is calculated in the mounting procedure selection routine 11 based on the program data 2 and the constant data 3 in the main controller 1, whereby the faster procedure is selected. Therefore, a loss in mounting time generated if the mounting procedure is a single procedure can be reduced and the mounting time per one board can be shortened. The using procedure can be set optionally through the operation panel 4.

According to the mounting method and apparatus of the embodiment, as is made clear from the foregoing description, the head section 35 can be selectively driven while one board is treated for mounting, according to the first mounting procedure whereby one electronic component is sucked and completely mounted and then the other electronic component is sucked and mounted and according to the second mounting procedure whereby two electronic components are sucked and then mounted. Through the suitable selection of the



mounting procedure, the loss in mounting time caused if the mounting procedure is one single procedure can be decreased, so that the mounting time per one board can be reduced.

Since the required mounting time in each procedure is calculated before the mounting is started and the procedure of a shorter required time is automatically selected, the mounting time for every board can be automatically shortened.

Further, the operation panel 4 installed as one means for the operator to select among the two mounting procedures enables optional selection of the mounting procedures.

Although the mounting time required in each procedure is calculated before the mounting in the above-described embodiment, if necessary, the mounting time may be calculated even during mounting thereby to suitably change the mounting procedure. For instance, although the mounting is started in accordance with the mounting procedure selected before the mounting in the above embodiment, in the case where the electronic components become short at the feed section in the middle of mounting, and consequently the suction position should be changed from the original one, the mounting time may be calculated again and an optimum mounting procedure may be re-selected. Data at which of the other suction positions of the electronic components of the same kind are arranged are recorded in the component feed section arrangement program 6, and therefore where to suck the electronic components of the same kind can be detected by reading the data in the event that the supply of the electronic components is interrupted.

Although the present invention has been fully described in connection with the preferred embodiments thereof with reference to the accompanying drawings, it is to be noted that various changes and modifications are apparent to those skilled in the art. Such changes and modifications are to be understood as included within the scope of the present invention as defined by the appended claims unless they depart therefrom.

## Claims

1. A method for mounting electronic components (16, 17, 18, 23, 24, 123) at an electronic component feed section (30) onto a board (32) with use of a head section (35) having a plurality of nozzles (12, 13) for sucking the electronic components and a recognition camera (15) for recognizing a posture of the electronic component sucked by each of the nozzles through its image, which comprises: sucking the electronic component at the feed section with use of the nozzles; image-recognizing the sucked posture of the electronic component by the recognition camera; correcting the sucked posture of the electronic component; and mounting the electronic component on the board in a corrected posture, whereby the head section is selectively driven while one board is subjected to mounting according to a first mounting procedure so that one component is sucked and the sucked component is mounted by one of the nozzles and a different component is sucked and the sucked component is mounted by the other of the nozzles and according to a second mounting procedure so that sucking by the plurality of nozzles is consecutively carried out and then mounting by the plurality of nozzles is conducted consecutively.
2. A mounting method according to claim 1, wherein a time required for mounting the electronic components according to each of the first and second mounting procedures is calculated before the mounting, and the mounting procedure of a shorter mounting time is selected to mount the electronic components.
3. A mounting method according to claim 2, wherein a required mounting time according to the first and second mounting procedures is calculated again if the electronic component to be sucked by the nozzles becomes short and a replacement electronic component is to be sucked at a suction position different from that of the original electronic component, so that the mounting procedure is re-selected.
4. A mounting method according to claim 2 or 3, wherein the mounting time in each of the first and second mounting procedures is calculated based on a time required for the head section to move to a mounting position for each of the electronic components, a time required for the head section to move to the suction position for each of the electronic components and a time required for recognizing and correcting the sucked posture of each of the electronic components.
5. A mounting method according to claims 1-4, wherein the first and second mounting procedures to be selected are optionally set by an operator.
6. An apparatus for mounting electronic components (16, 17, 18, 23, 24, 123) at an electronic component feed section (30) onto a board, which comprises: a head section (35) having a plurality of nozzles (12, 13) for sucking the electronic components and a recognition camera (15) for recognizing a posture of the electronic component sucked by each of the nozzles through images; and a control part (1) which controls the head section so that, after the electronic components at the feed section are sucked by the nozzles, the sucked postures of the electronic components are image-recognized by the recognition camera and the sucked postures to



the head section are corrected, the components are mounted on the board wherein the control part is provided with a mounting procedure selection means (11) for selectively driving the head section while one board is subjected to mounting according to a first mounting procedure whereby one component is sucked and the sucked component is mounted by one of the nozzles and a different component is sucked and the sucked component is mounted by the other of the nozzles and according to a second mounting procedure whereby sucking by the plurality of nozzles is consecutively carried out and then mounting by the plurality of nozzles is conducted consecutively.

7. A mounting apparatus according to claim 6, wherein the mounting procedure selection means is provided with a mounting time calculation means (11) for calculating a time required for mounting of the electronic components according to the first and second mounting procedures and automatically selecting the mounting procedure of a shorter mounting time based on the calculations for the two mounting procedures.
8. A mounting apparatus according to claim 7, wherein the mounting time calculation means is constituted to calculate the mounting time in each of the first and second mounting procedures based on a time required for the head section to move to a mounting position on the board for each of the electronic components, a time required for the head section to move to the suction position at the feed section for each of the electronic components and a time required for recognizing and correcting the sucked posture of each of the electronic components.
9. A mounting apparatus according to any one of claims 6-8, wherein a means (4) is provided allowing an operator to optionally set the mounting procedure to be selected by the mounting procedure selection means.

*Fig. 1*

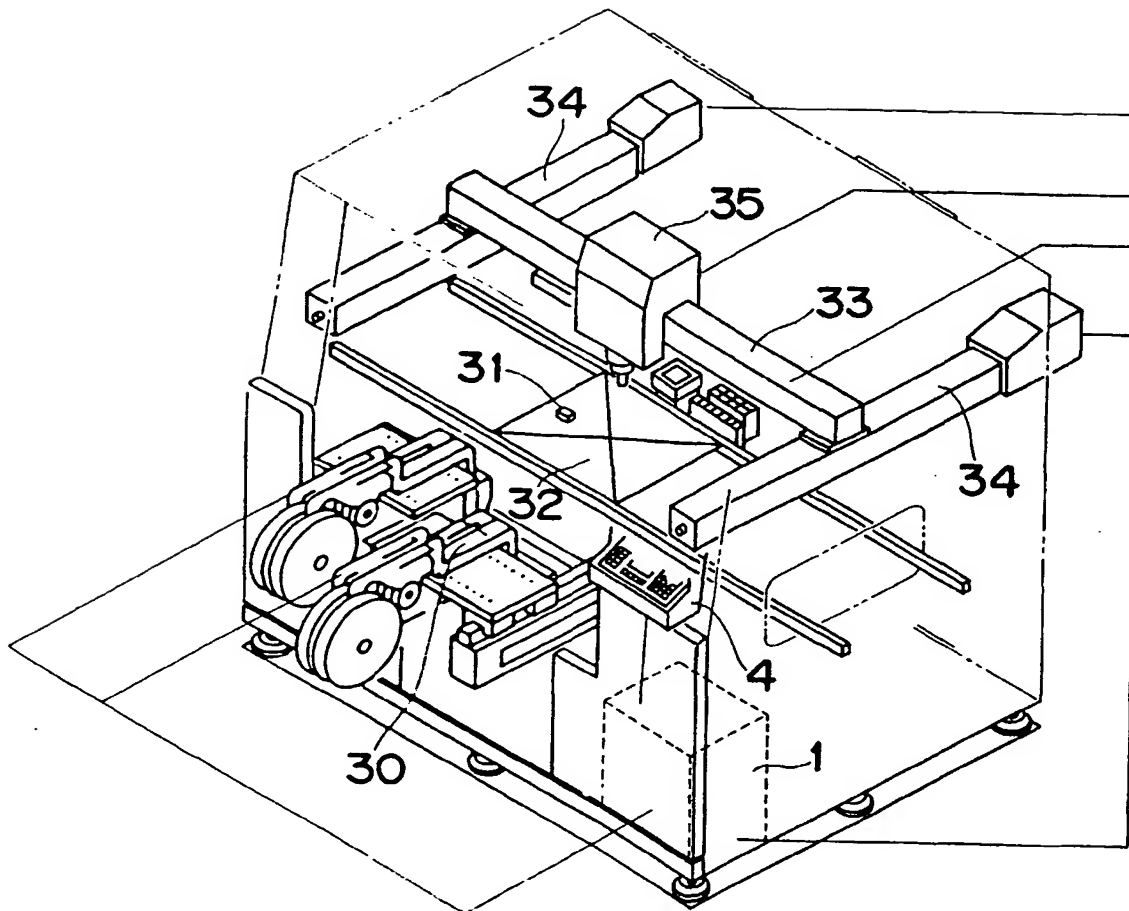
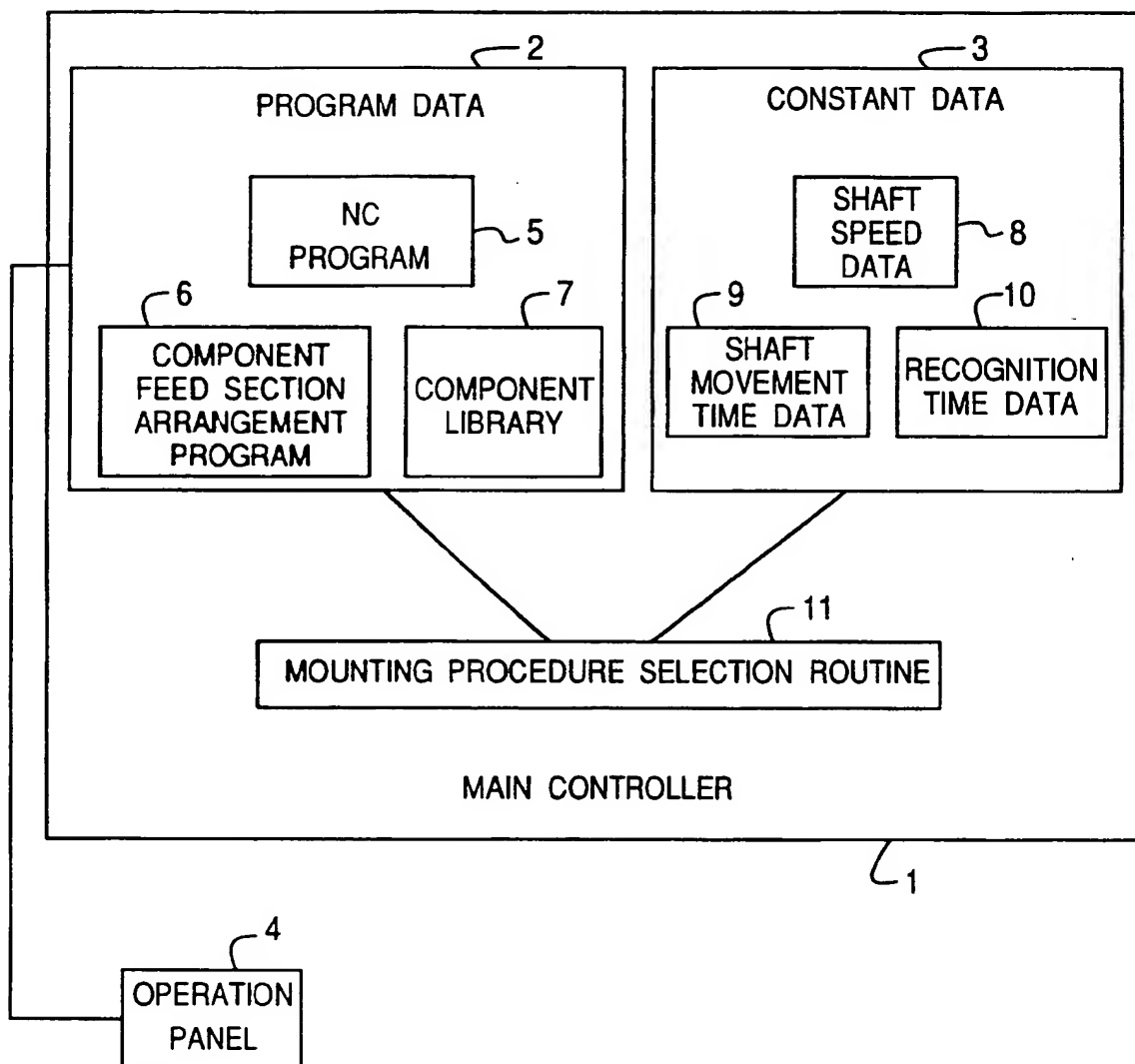
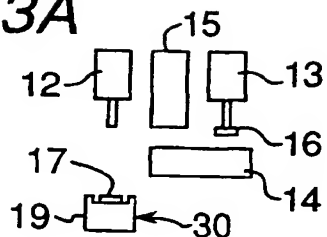


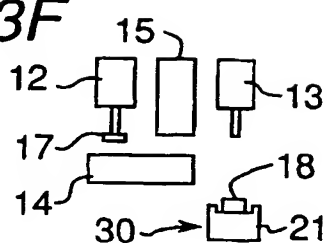
Fig.2



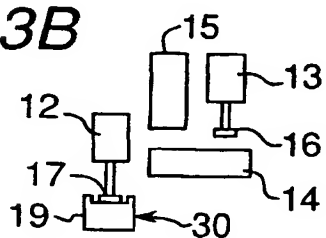
**Fig.3A**



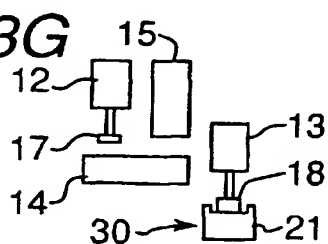
**Fig.3F**



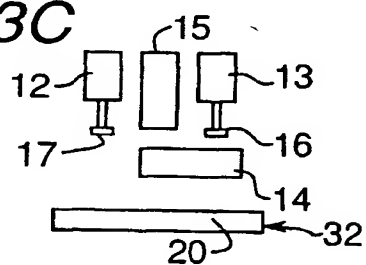
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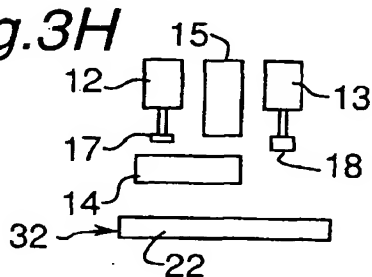
**Fig.3G**



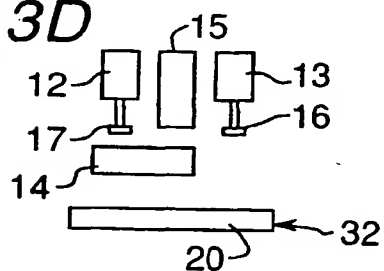
**Fig.3C**



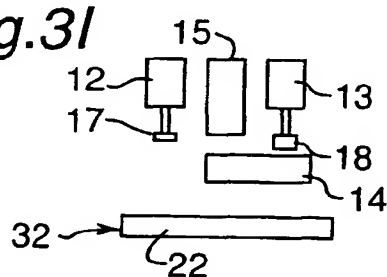
**Fig.3H**



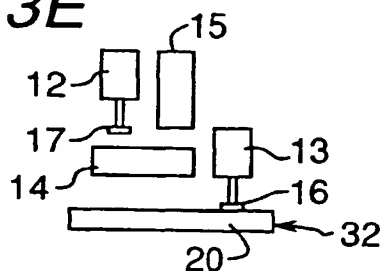
**Fig.3D**



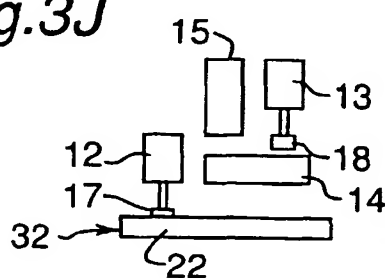
**Fig.3I**



**Fig.3E**



**Fig.3J**



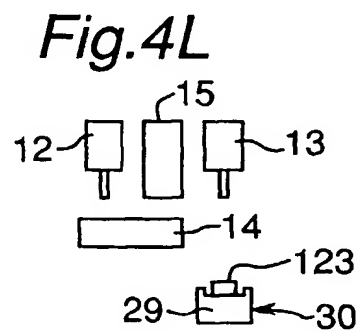
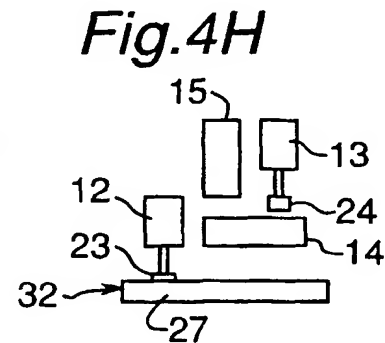
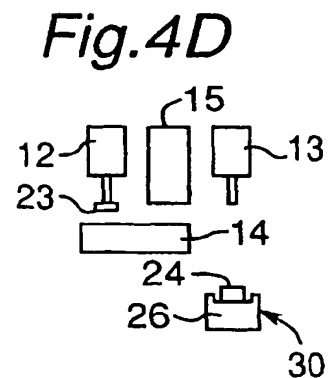
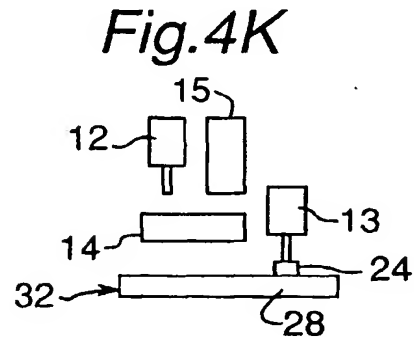
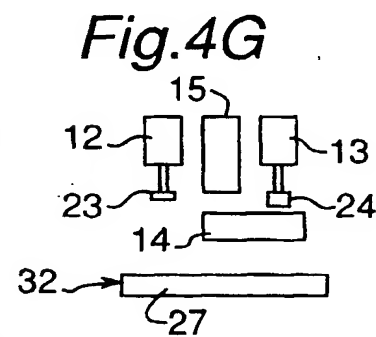
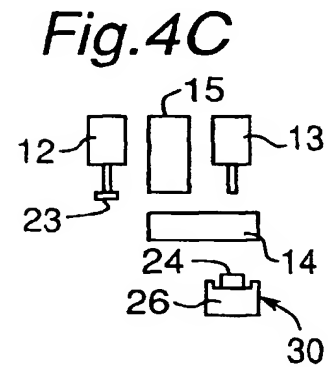
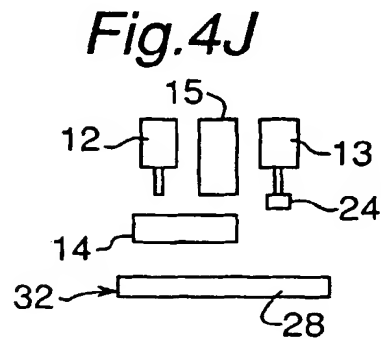
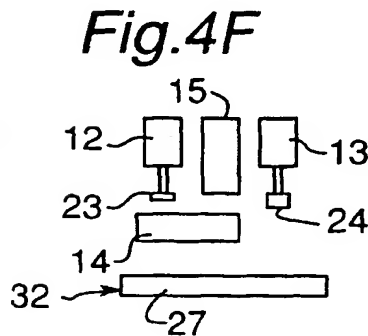
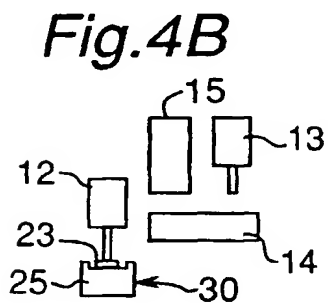
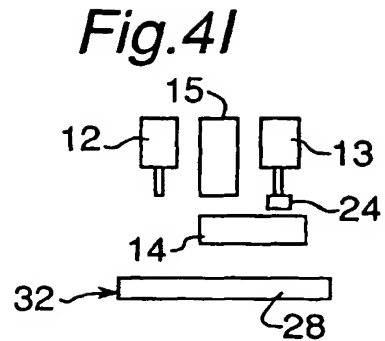
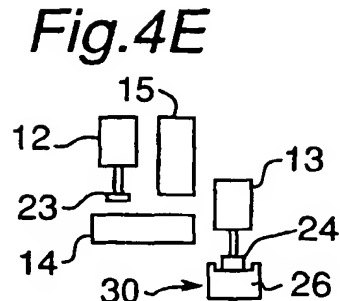
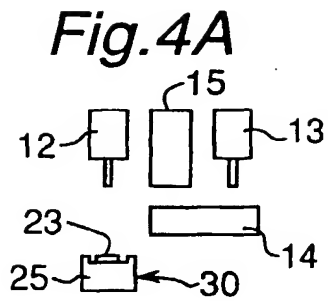


Fig. 5

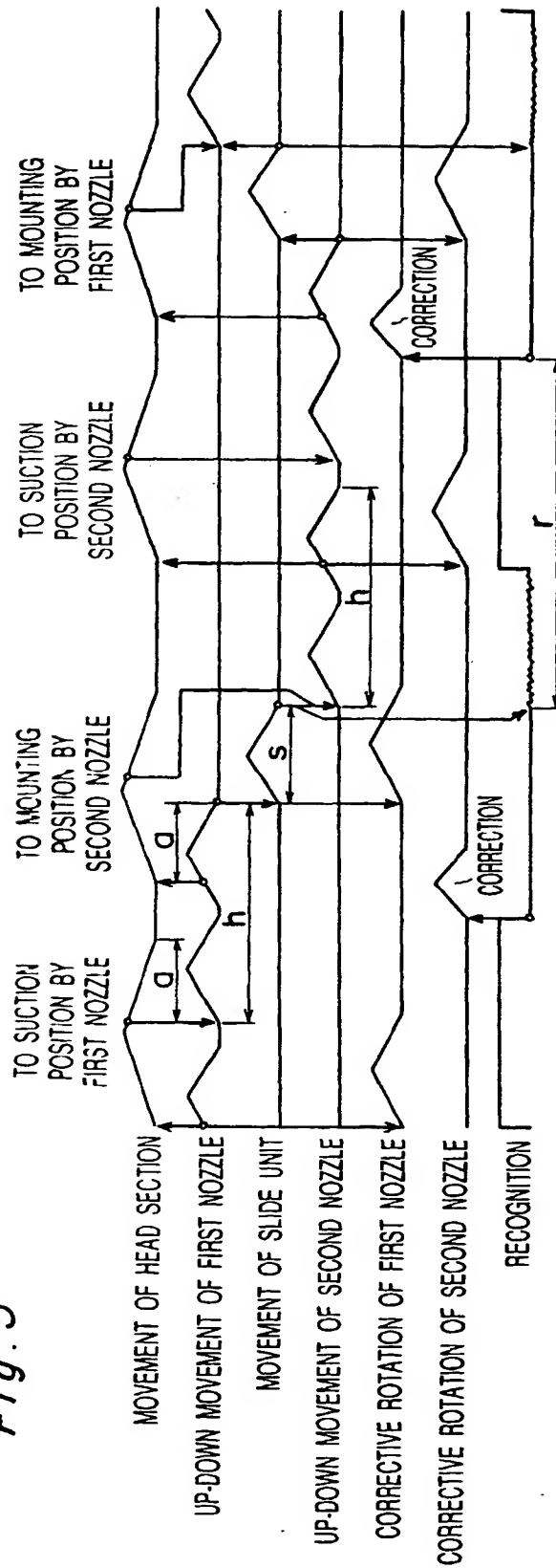
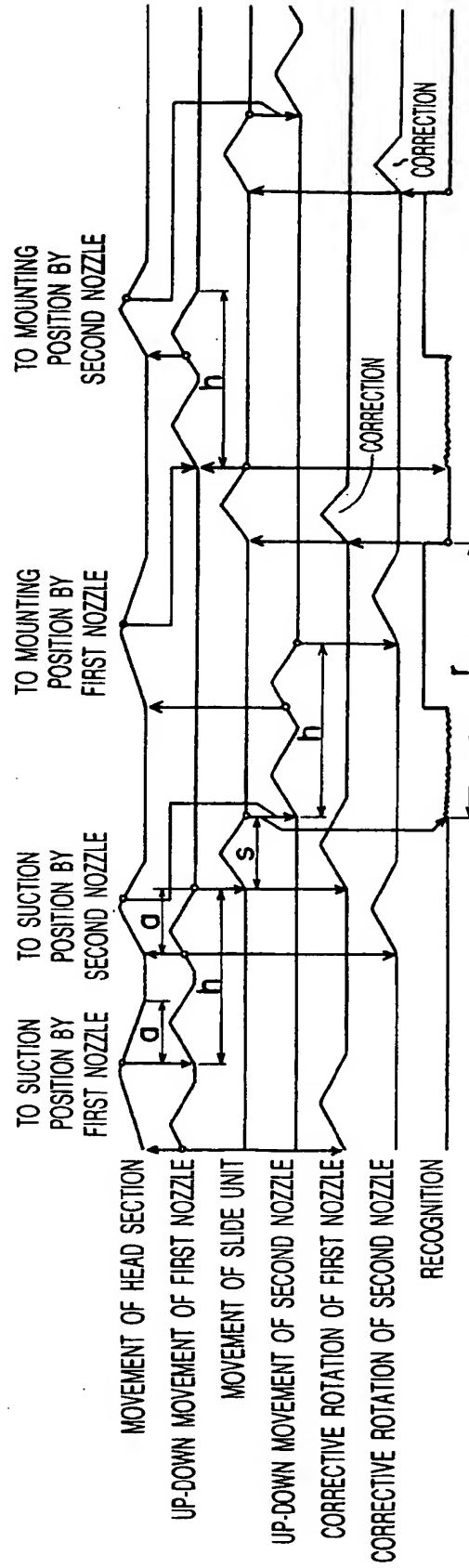


Fig. 6





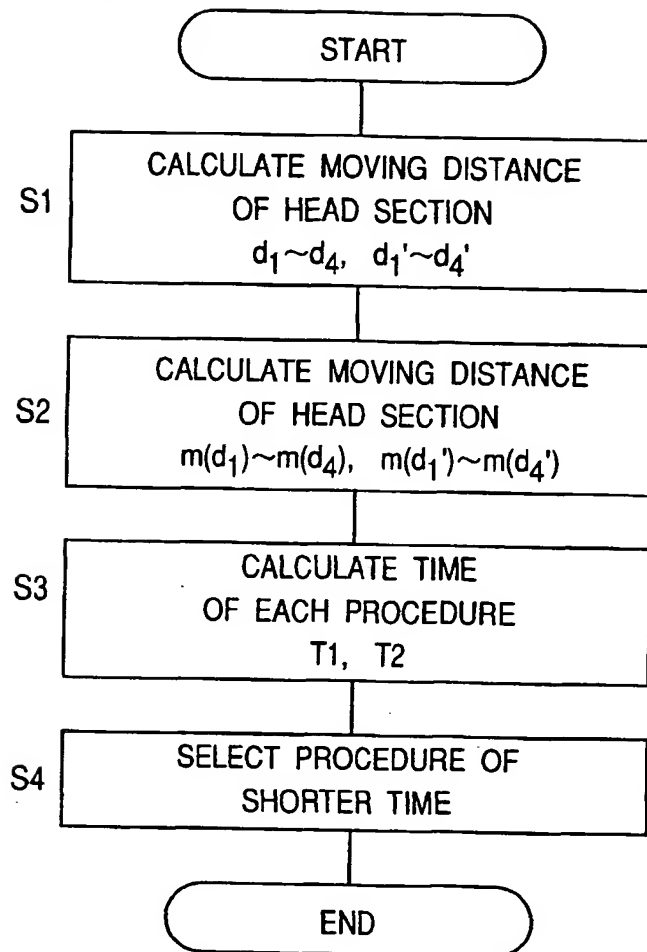
*Fig.7*

Fig. 8A

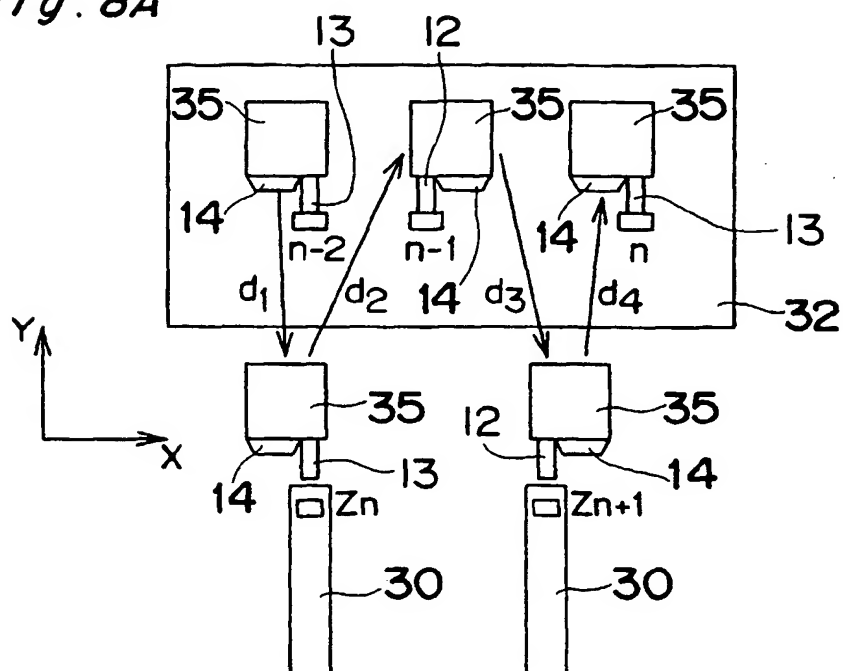
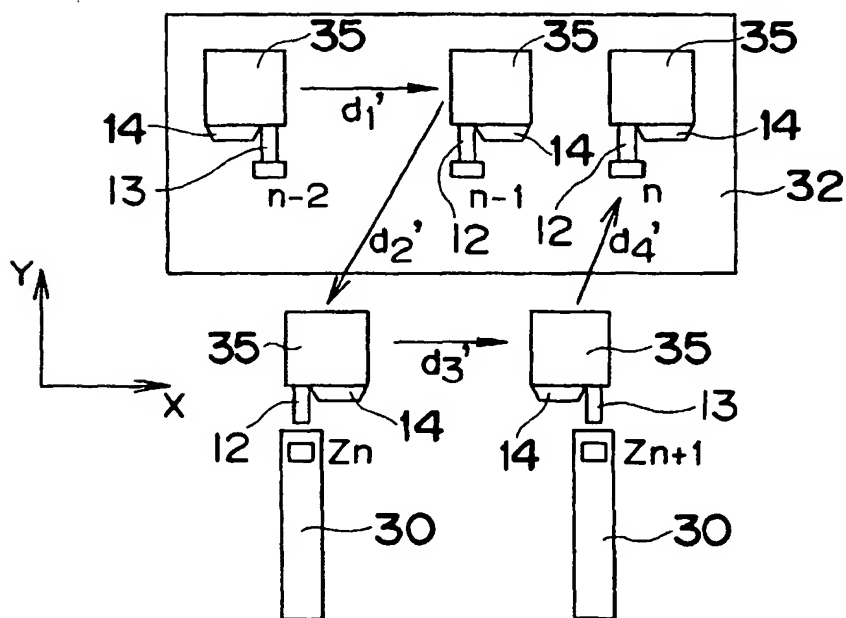
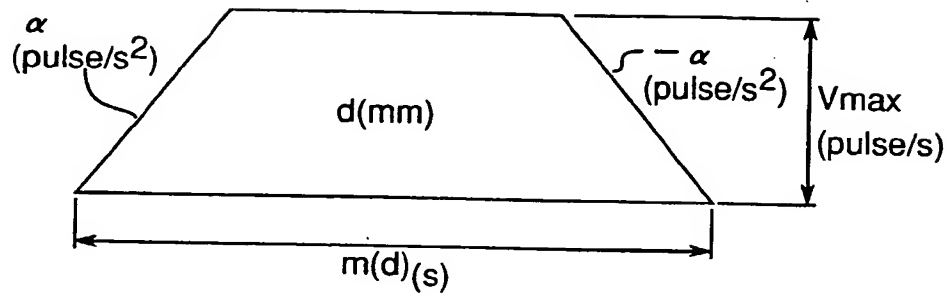
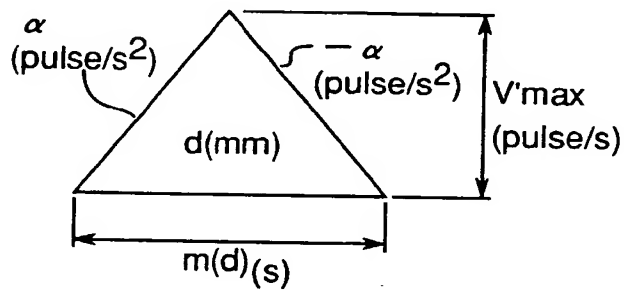
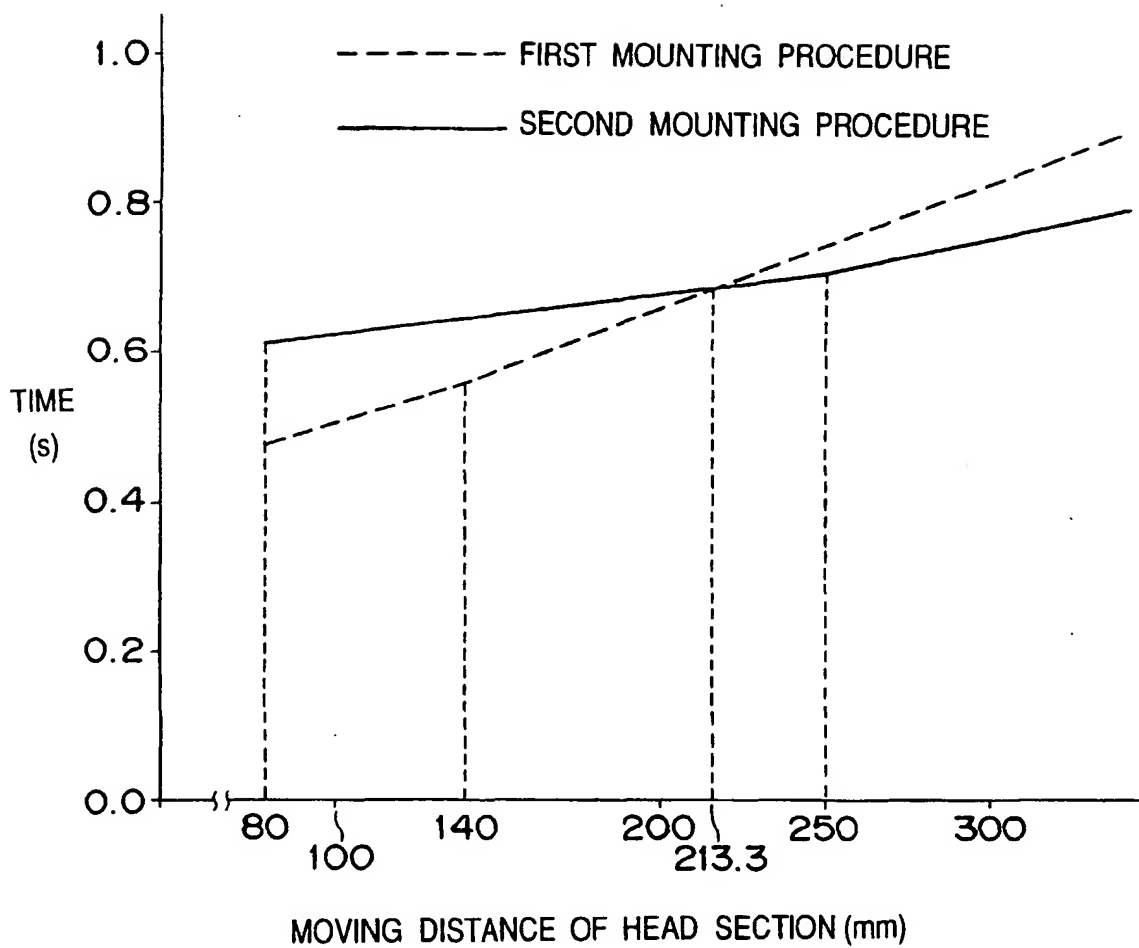


Fig. 8B

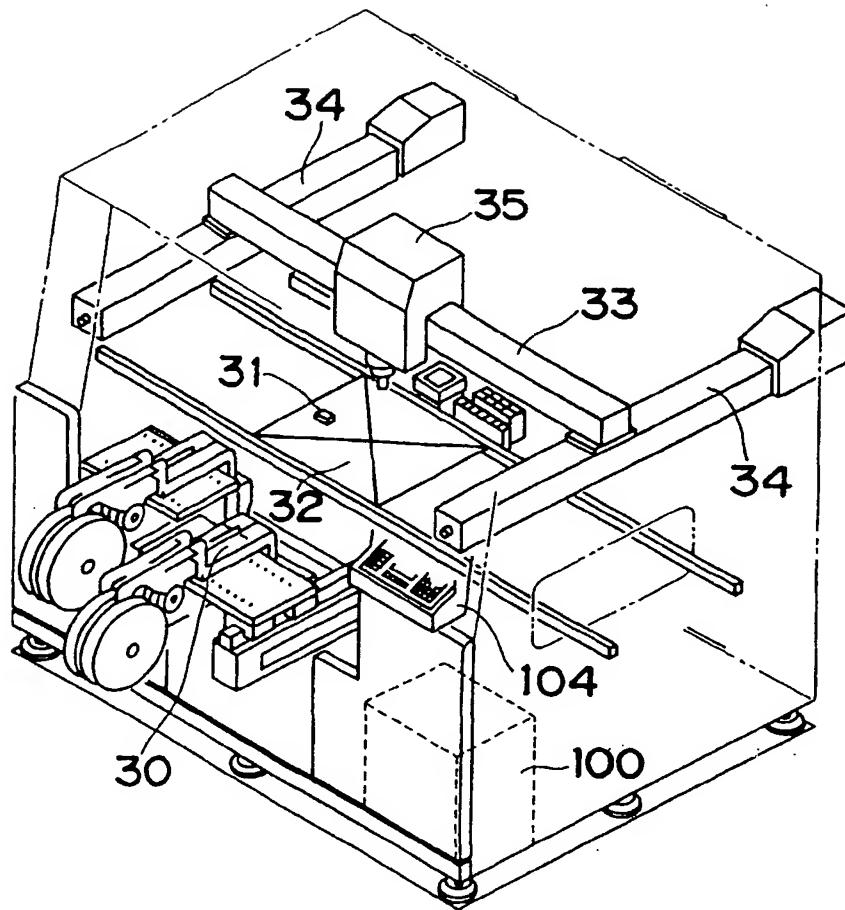


*Fig.9A**Fig.9B**Fig.10*

DATA NAME	PARAMETER	SYMBOL(UNIT : s)
SHAFT MOVEMENT TIME DATA	SUCKING / MOUNTING TIME	h
	ARCH MOTION TIME	a
	MOVING TIME OF SLIDE UNIT	s
RECOGNITION TIME DATA	SUCKING / MOUNTING ATTITUDE RECOGNITION TIME	r

*Fig. 11*

*Fig. 12*



## INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP96/01928

<b>A. CLASSIFICATION OF SUBJECT MATTER</b>		
Int. Cl <sup>6</sup> H05K13/04		
According to International Patent Classification (IPC) or to both national classification and IPC		
<b>B. FIELDS SEARCHED</b>		
Minimum documentation searched (classification system followed by classification symbols)		
Int. Cl <sup>6</sup> H05K13/00-13/08, B23P21/00		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Jitsuyo Shinan Koho 1926 - 1996 Kokai Jitsuyo Shinan Koho 1971 - 1996 Toroku Jitsuyo Shinan Koho 1994 - 1996		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)		
<b>C. DOCUMENTS CONSIDERED TO BE RELEVANT</b>		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP, 6-61694, A (Yamaha Motor Co., Ltd.), March 4, 1994 (04. 03. 94) & US, 5377405, A & EP, 578136, A3	1 - 9
A	JP, 4-346297, A (Matsushita Electric Industrial Co., Ltd.), December 2, 1992 (02. 12. 92) (Family: none)	1 - 9
<input type="checkbox"/> Further documents are listed in the continuation of Box C. <input type="checkbox"/> See patent family annex.		
* Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier document but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another claim or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
Date of the actual completion of the international search		Date of mailing of the international search report
September 30, 1996 (30. 09. 96)		October 8, 1996 (08. 10. 96)
Name and mailing address of the ISA/ Japanese Patent Office		Authorized officer
Facsimile No.		Telephone No.

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